Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

UNDERSTANDING RADIATION

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Canada

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WHAT IS RADIATION?

Radiation is energy in motion in the form of waves or streams of particles. There are many kinds of radiation all around us. Sound and visible light are familiar forms of radiation. Other types include ultraviolet radiation, which produces a suntan, infrared radiation, which is a form of heat energy, and radio and television signals.

When most people hear the word radiation, they often think of atomic energy, nuclear power, and radioactivity. The energy in this kind of radiation can cause changes in atoms, creating electrically charged atoms which we call ions. Radiation which produces ions is called ionizing radiation.

All life has evolved in an environment filled with ionizing radiation. However, unlike heat and light, ionizing radiation is invisible to our senses. You can't feel, see, hear, taste, or smell it. Before 1895 we didn't even know it existed. Special instruments, such as the Geiger counter, allow us to detect and measure ionizing radiation.

The forces at work in ionizing radiation are revealed when you look at the structure of atoms. Atoms are so small that a single human hair is a million times thicker, but small as they are, atoms are made of even smaller particles which are electrically charged. Particles called protons have a positive charge while electrons have an equal negative charge. A third particle called a neutron has no charge.

In most atoms, there is an equal number of protons and electrons so there is a balance of positive and negative charges, resulting in the entire atom having a neutral charge.

Everything in the world and the universe is made up of atoms, which make up a family of more than 90 different elements. The number of protons in an atom determines the kind of element the atom is. For example, all atoms with one proton are hydrogen and atoms with two protons are helium.

While all the atoms of a given element have the same number of protons, the number of neutrons can vary. Atoms with the same number of protons, but a different number of neutrons, are called isotopes. Nearly all the elements have two or more isotopes.

For example, hydrogen has three isotopes: H-1 (hydrogen), H-2 (deuterium), and H-3 (tritium). While all three have a single proton, hydrogen has no neutrons, deuterium has one neutron, and tritium has two neutrons.

Most atoms are stable isotopes, which means that the balance of protons and neutrons is such that these atoms never change. However, in some isotopes, the number of protons and neutrons causes the atoms to be unstable. For example, hydrogen-3 (tritium) and uranium-238 are unstable isotopes. In an attempt to become stable, these atoms release energy by ejecting particles in the form of alpha, beta, or gamma radiation.

Atoms which are unstable and emit this radiation are called radioactive isotopes, or radioisotopes.

Since radioisotopes are unstable, they release energy until they finally become stable and therefore, non-radioactive. This process is called radioactive decay.

The term half-life refers to the amount of time it takes for half of the radioactive atoms of a certain type to decay. For example, the half-life of tritium is about twelve years, which means that, in a given quantity of tritium, only half the radioactive atoms will remain unchanged after this period. After another twelve years, only half of the number will remain, and so forth until nearly all the atoms have become stable.

While some radioisotopes decay very quickly, in a matter of seconds, others decay over billions of years.

Decay Rates of Some Unstable Isotopes

Name	Half-life
Polonium-214	.00016 seconds
Iodine-123	13 hours
Radon-222	3.8 days
Tritium (Hydrogen-3)	12.3 years
Radium-226	1600 years
Uranium-238	4.5 billion years

TYPES OF IONIZING RADIATION

Alpha Radiation: Alpha particles consist of two protons and two neutrons, and carry a positive charge. Alpha particles are barely able to penetrate skin and can be stopped completely by a sheet of paper.

Beta Radiation: Beta radiation consists of fast moving electrons ejected from the nucleus of an atom. More penetrating than alpha radiation, beta radiation is stopped by a book or human tissue.

Gamma Radiation: Gamma radiation is a very penetrating type of radiation. It is usually emitted immediately after the ejection of an alpha or beta particle from the nucleus of an atom. It can pass through the human body, but is almost completely absorbed by denser materials such as concrete or lead.

X-rays: X-rays are a form of radiation produced mainly by artificial means rather than by naturally occurring radioactive substances.

Neutrons: Less common, neutron radiation occurs when neutrons are ejected from the nucleus by nuclear fission and other processes. The nuclear chain reaction is an example of nuclear fission.

NATURAL SOURCES OF IONIZING RADIATION

Ionizing radiation is a natural part of the world. You receive small amounts of radiation from uranium and other radioactive elements which are found everywhere in rocks and soil. As these naturally occurring radioactive materials decay and change, some of them produce a radioactive gas called radon, which is present in small amounts in the air we breathe.

We also receive cosmic radiation from the sun. Most of this radiation is stopped by the atmosphere, but some does get through. People who live at higher altitudes or who frequently travel by airplane are exposed to more cosmic radiation than those who do not.

All of us have very small amounts of naturally occurring radiation in our own bodies. We absorb these substances from the foods we eat and drink, and from the air we breathe.

The sum of all this natural radiation is called background radiation. It accounts for about 80% of the radiation which an average Canadian receives in a lifetime. The other 20% comes from artificial sources.

ARTIFICIAL SOURCES OF RADIATION

The production of radiation by artificial means began in 1895 when X-rays were discovered. In the following two decades many of the naturally occurring radioactive elements were identified.

Scientists devised theories to explain the structure of atoms and the forces at work inside them. Putting these theories to work, they discovered ways to create and control artificial sources of radiation. In 1942, the first nuclear reactor went into service in the United States and five years later, Canadian scientists started up Canada's first reactor at Chalk River, Ontario.

With the means to produce radiation artificially, scientists inherited a responsibility to control its use and to understand its effects. Those first pioneers of radiation knew little about the harm it could cause, but they soon realized that ionizing radiation could have damaging effects upon living organisms.

New research was devoted to finding ways to protect people and these studies gave rise to new sciences such as health physics.

BIOLOGICAL EFFECTS OF RADIATION

When ionizing radiation penetrates living tissues the chemical structure of living cells can change. If enough radiation is absorbed, cells may be altered or destroyed. Living tissue has a great ability to repair itself, but in some cases these cellular changes can develop into cancer. They could also cause genetic damage or birth defects.

These effects are most likely when a person is exposed to high or moderate levels of radiation. However, exposure to a large amount of radiation would be unusual and unlikely. Even exposure to moderate levels occurs only under the rarest of circumstances.

When exposure to lower levels of radiation is examined, it's more difficult to predict the effects. In any given population, some people will get cancer or pass on genetic defects. This is a normal process in the natural order of life. Exposure to air pollution, toxic chemicals, sunlight, viruses, smoking, etc. may contribute to the incidence of health effects. But since we know radiation can cause these effects, to be on the safe side, nuclear regulators assume that there is some risk involved at low doses and take appropriate measures to protect health and safety.

HOW DO WE USE RADIATION ?

Used properly, and with care, radiation can offer many benefits. Radiation is used when the benefits outweigh the potential risks. For example, using X-rays for medical diagnoses has more potential benefits than potential risks.

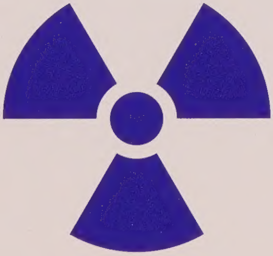
Radioisotopes are used for many medical diagnostic procedures and for the treatment of cancer. Radiation is also used to sterilize objects in medicine and in other fields.

Radioisotopes are used in a number of consumer products such as smoke detectors and emergency exit signs. For security, X-rays are used at airports to inspect baggage. Industries also use radiation to inspect structural welds in pipelines and in shipbuilding.

Radiation is also used for scientific research. Naturally-found radioisotopes play an important role in dating archaeological artifacts. X-rays also help determine the authenticity of artwork. In agriculture, radioisotopes help scientists develop new strains of plants and track the habits of insects and pests.

The study of physics is one of the purposes of nuclear reactors. Reactors and particle accelerators are used to create new radioisotopes used in medicine and industry. In addition, nuclear reactors are also used to generate electrical power.

This universal symbol, the trefoil, warns us wherever there is a potential for exposure to radiation. This includes work areas, waste and storage facilities, and all packages and shipments which contain radioactive materials.



PROTECTING PEOPLE AND THE ENVIRONMENT

Radiation protection principles

People who work in areas with radioactive materials, such as uranium mines, reactors, or radiology units at hospitals, have a greater need for protection. Three primary means are used to protect them from radiation: time, distance, and shielding.

Time: The shorter the period of exposure to radiation, the less radiation will be absorbed. When possible, people who work in radiation areas must reduce the time that they spend near radioactive sources.

Distance: The intensity of ionizing radiation, like the radiation of visible light, rapidly decreases with distance. By increasing the distance from a radioactive source, the amount of exposure is reduced.

Shielding: People working with or near radiation sources are protected by barriers which include shielding of lead, concrete, and other heavy materials. Protective clothing provides protection against some types of radiation.

People who work near radioactive materials routinely wear devices called dosimeters. These devices monitor and record ionizing radiation doses to guard against the possibility of overexposures.

Environmental Monitoring

Environmental radiation monitoring programs are carried out in the vicinity of nuclear power stations and at other locations across Canada to protect people and the environment from the potential effects of radiation. There are a number of government and industry programs in place to observe and record the levels of radiation in the environment, either from naturally occurring radioisotopes, or as a result of emissions from different nuclear facilities.

These programs measure levels of radioactivity in the air, in drinking water, in surface water, in the soil, and in food. Data is routinely gathered for a wide variety of uses. With this data, the Canadian Nuclear Safety Commission (CNSC) can verify that standards are being met, evaluate the effectiveness of controls and determine environmental trends.

Our commitment to Canadians

At the CNSC, our business is regulation and our job is safety. The CNSC regulates Canada's nuclear industries to protect nuclear industry workers, all Canadians, the environment and to respect Canada's international commitments on the peaceful use of nuclear energy.

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